THURSDAY, APRIL 12, 1906.

THE PHYSIOLOGICAL EFFECT OF LIFE IN THE ALPS.

Höhenklima und Bergwanderungen in ihrer wirkung auf den Menschen. By N. Zuntz, A. Loewy, F. Müller, and W. Caspari. Pp. xvi+494, and tables. Dedicated to E. Pflüger, in celebration of the jubilee of his doctorate. (Berlin: Bong and Co., 1905.)

ALPINE literature has a special charm; it re-kindles memories of happy hours spent among the mountains, and thrills us with echoes of that intense delight in life which was the prominent characteristic of days in Switzerland. No doubt many things contribute to the pleasure which the Alps give to thousands of men and women, but one obvious and potent factor is the sense of well-being; we feel that, like the elixir of life, mountain air and scenery rejuvenate body and mind.

In the important work just published by Prof. Zuntz, Prof. Loewy, and their comrades, a scientific basis is afforded for this rejuvenating influence. The volume contains an account of an expedition undertaken expressly to carry out physiological investigations at high altitudes. Such expeditions have been frequently made, the most notable being the pioneer one of Paul Bert, the extensive one of Kronecker and his colleagues, and those which Mosso has repeatedly carried out in the Monte Rosa district. The expedition conducted by Prof. Zuntz has no doubt reaped great advantages from the study of the work of its predecessors, and the results achieved are in consequence more convincing, and from the physiological standpoint more valuable.

Since the object of the expedition was the enlargement of physiological science, the essential features of the account are of necessity somewhat technical. But the volume contains many passages which are of general interest, including an extensive historical account of earlier expeditions. There are in every one of the twenty-two chapters passages which will appeal to all those who love the Alps, for Prof. Zuntz is himself one of this fraternal band, and reveals his own enthusiasm not only by the character of the descriptive writing, but more directly by the interpolation of many beautiful Alpine illustrations. Moreover, such practical details as clothing, food, and exercise are dealt with from the alpinist's point of view, and what is termed "sport" is treated in a most suggestive way.

To the majority of readers, especially if they should be medical practitioners, the most interesting portions of this really great work will be those which set forth the peculiarities of the climate in high altitudes and the influence which these peculiarities must exert, not only on vigorous athletes who climb the topmost peaks, but on the ever-increasing number of less ambitious mortals who seek the Alps in order to restore shattered health, or to check the advance of disease. In chapter xx. the benefits and dangers of life in moderately high altitudes are set forth in the light of the results of the expedition; the new basis for estimating the value of such benefit or the extent of such danger which is given in this part of the work should of itself secure the general reputation of the volume owing to its direct bearing upon some of the most important hygienic topics of the day.

It is impossible in the short space of this notice to do justice to such a comprehensive volume, but since the essence of the work lies in the physiological effects which were observed at high altitudes, and these form the basis referred to in the preceding paragraph, a brief summary of the physiological results must be attempted. In order to realise their nature, the plan of the expedition will be first described.

Two physiological professors, two assistant professors, and two younger members of the medical profession engaged in physiological research formed the *personnel* of the expedition. For more than twelve months each member of the party had made elaborate experiments of a preliminary character in the Berlin laboratories in order to become efficient in the quantitative work necessary for the investigation of the body metabolism. The details of the expedition were planned with great care and forethought; valuable aid was afforded by Prof. Kronecker, of Berne, and Prof. Mosso, of Turin, the most essential feature of this help being the offer of the working laboratories established in the Brienz district by Kronecker and in the Monte Rosa district by Mosso. In July, 1901, the actual work was begun at Brienz. This is situated at the east end of the lake of that name, and lies at the height of 1857 feet; it is connected by a mountain railway with the summit of the Brienz Rothhorn (7713 feet). At Brienz each member of the party, by strict diet and other precautions, placed himself in a condition of nitrogenous equilibrium, that is, a condition in which the quantity of nitrogen assimilated from the food is equal to that excreted in twenty-four hours. After a few days the party divided, three members going by train to the summit of the Brienz Rothhorn, the others remaining at the lower level both groups performed given amounts of muscular exercise and conducted similar physiological investigations. Finally the groups changed places, and the work was continued as before. This formed the first part of the inquiry; the second part was of a more severe character. Starting from that delightful valley in which Gressoney-la-Trinité nestles amongst the flowery slopes of the Lysthal, the party ascended to the Col d'Olen, where, at a height of 9420 feet, Mosso has established his lower mountain laboratory. After spending some days in preparations, four members of the party and Prof. Sella, of Rome, climbed with guides and porters to the summit of the Signal Kuppe or Point Gnifetti of Monte Rosa, 14,965 feet. Here they stayed for seven days in the hut, now widely known as the Capanna Osservatorio Regina Margherita, which was erected for experimental purposes through Mosso's endeavours. The first days were most tempestuous, and the account of the stay on the summit is full of interest; an incident in the week was the recovery of a collapsed Alpine tourist, who, to the surprise of the party, turned out to be a lady. The whole party suffered more or less severely from mountain sickness, and a valuable part of the investigations deals with this familiar complaint.

Animals were taken up all the ascents for experimental purposes, others being left below for control observations.

The physiological results are related respectively to the influence of moderate altitudes, *i.e.* up to 7500 feet, and of high altitudes up to nearly 15,000 feet, the former being chiefly the Brienz-Rothhorn experiments, the latter the Monte Rosa ones. They may be briefly summarised under the following different headings:—

(1) *Blood Changes.*—It is now well known that, as first suggested by Paul Bert, the blood is altered in high altitudes. The most striking change is that discovered by Viault, who found that the red blood corpuscles increased from five millions to seven or eight millions per cubic millimetre of blood. Similar increase was observed in the present expedition, but it was somewhat uncertain in character. The determination of the specific gravity of the blood and of the serum showed that the increase when present was not due to plasma diminution through the excessive evaporation of perspiration; moreover, an examination in animals of the tissue which is the seat of the corpuscular formation (the red marrow of the bones) showed that this was in a state of greatly augmented activity. There is therefore no question that the red corpuscles increase in number, and the authors state in their work that the stimulating influence is the diminished oxygen tension of the blood itself.

(2) *Digestive Efficiency.*—By careful quantitative examinations of the food and excreta, it was shown that altitudes up to 8000 feet exercised a favourable influence upon the completeness of the digestive processes, the indigestible residues diminishing especially when the surroundings were cold. In very hot surroundings this favourable influence was not so apparent, and in these circumstances muscular exertion caused it to be of the reverse type. At very high altitudes, 14,900 feet, the efficiency of digestion was greatly impaired.

(3) *Oxidation Processes.*—The extent of these was determined by the relation between the absorbed oxygen and the total heat production of the body. It appeared that even at such low altitudes as 1500 feet the total oxidation was increased, this being exceptionally high during muscular exertion, whilst in moderate and high altitudes the oxidation processes were greatly increased. The increase is set down to two circumstances; firstly, the diminished thermogenetic capacity of the muscles, which are impaired by the inadequate supply of oxygen in their circulating blood, thus throwing the necessary heat production upon the oxidation of more complex compounds than those offered by the muscles; secondly, the presence in the tissues of abnormal oxidisable substances.

(4) *Proteid Metabolism.*—The most important of the numerous changes brought forward in the results of the expedition are those connected with the fundamental nitrogenous substances, proteids. It has been firmly established in physiology that whilst every growing animal assimilates through food more nitrogen than is excreted, this is not the case in the adult except in special circumstances. Growth implies proteid storage, which is believed to be utilised for the increased formation of cellular structures, and even in the adult such local muscular growth may occur as the result of special muscular exercise, training, &c., but it soon reaches a limit and is comparatively insignificant. In the convalescent it is a marked feature of recovery from wasting illness. After making due allowance for all disturbing influences, a most important result was arrived at by the work of the expedition. Even at Brienz (1500 feet) a stage was reached in which the total N-import exceeded the N-export, whilst on the Rothhorn this excess was most marked. Moreover, this phase of metabolism persisted for a considerable time after leaving the moderately high altitude. This implies the production of a phase of nitrogenous metabolism resembling that of the growing animal; it is, in short, a renewal of youth. It is noteworthy that along with this nitrogen storage there was no corresponding increase of body weight, the intensity of the oxidation processes in non-nitrogenous compounds being more than sufficient to mask the proteid gain. At the highest altitudes the gain was not so apparent, but this is amply accounted for by the digestive derangement which was associated with the mountain sickness.

(5) *Respiration and Circulation.*—The decrease of the oxygen tension in the blood in consequence of the decreased partial pressure of the oxygen of the air was in accordance with the results obtained by Hüfner and others in connection with hæmoglobin. In opposition to Mosso's results the authors found that there was not a decreased tension of carbonic acid in the blood. They bring forward evidence which suggests that deficiency of oxygen in the blood can, like excess of carbonic acid, stimulate the respiratory centre; this is of interest as it is opposed to the physiological view now generally accepted. The peculiar type of breathing known as the Cheyne-Stokes respiration, described by Mosso as occurring at high altitudes, was observed by the members of the expedition on Monte Rosa, but the explanation now advanced is quite different from that offered by Mosso. Zuntz regards the phenomenon as impaired activity of the respiratory centres, which are only capable of being adequately roused if the carbonic acid has by accumulation reached a certain tension in the blood.

As regards the circulatory changes, the only one of a fundamental character appeared to be due to the altered activity of the heart. At moderate altitudes the heart's activity, like that of the respiratory mechanism, is augmented to meet the need for more oxygen and more effective oxygen transport by the blood, but at very high altitudes there appeared to be a great tendency to cardiac weakness owing to the direct action of insufficient oxygen in the blood supplying the muscular walls of the heart.

This scanty and imperfect sketch may serve to show the very extensive field which is covered by the physiological work of the expedition, but, in addition, many valuable observations were made upon the symptoms, progress, and nature of mountain sickness. The cause of this complaint is, according to the authors, the deficiency of oxygen transport by the blood. The individual variations in the manifestation of the symptoms and the disappearance of the symptoms on habituation are considered to be due to the relative adequacy or inadequacy of the mechanisms by which the organism endeavours to protect itself against this oxygen deficiency. One such mechanism is the circulation flow, and if this is unable to bear the strain of increase, then nervous influences diminish the vascular area of the digestive organs in order to supply, so far as practicable, the higher nerve centres in the brain; in consequence of this anæmia, an extensive derangement of the digestive functions is produced which shows itself in the sickness and other symptoms that are the characteristic features of the trouble.

In conclusion, attention must be directed once again to the practical bearing of the Rothhorn experiments. These deal with the effects produced by moderately high altitudes, and to such altitudes thousands of men and women go every year, whilst the numerous sanatoria frequented by invalids are situated at these elevations. Moderate altitudes of less than 8000 feet appear, in consequence of the lessened atmospheric pressure, to benefit the whole organism in the following particulars. The tissue which produces the oxygen carriers of the blood is stimulated into greater activity, the oxidation of abnormal substances is increased, the heart's action is augmented, the respiratory muscular mechanism is brought into more energetic use, and, finally, that proteid assimilation which is so directly related to cell growth and cell restoration assumes the phase present in the young and growing animal. In consequence of all these changes, and particularly the last one, altitudes of from 4000 to 7000 feet must exercise a most beneficial and even rejuvenating influence. In the case of many invalids the effect will be to arm the body for its fight against such insidious foes as the tubercle bacillus and to hasten recovery in all cases of convalescence from bodily or mental prostration. Only those whose circulation is seriously impaired directly or indirectly by organic disease are debarred from the probability of such beneficial effects.

Experience has revealed to many the profound truth which is expressed in the beautiful and familiar words, "I will lift up mine eyes unto the hills, from whence cometh my help." In their monumental work Prof. Zuntz and his colleagues present physiological reasons for the assurance that whilst mountain scenery may arouse the imagination, mountain air will stimulate those organic functions which form the foundation for health of body and happiness of mind.

F. G.

A COMPREHENSIVE DYNAMICS FOR PHYSICISTS.

The Dynamics of Particles and of Rigid, Elastic, and Fluid Bodies. By Prof. Arthur Gordon Webster. Pp. xii+588. (Leipzig: B. G. Teubner, 1904.) Price 10 marks.

ATTENTION has been directed in more than one recent review to the tendency to over elaboration in the standard treatises to which an English reader would naturally turn for information on such branches of applied mathematics as the principle of least action, the potentials of ellipsoids, or the equations of motion of a perfect fluid. What has been said already must be said again, in order to make good the claims which Prof. Webster puts forward in his preface, and to prove that this book, written by an American and published in Germany, fills a distinct want.

That the student of physics should have to consult five volumes of Routh, three of Love, and a large work of Lamb is a state of affairs which could not very well be allowed to continue. It is true that these treatises afford an excellent preparation for the man who proposes to devote his whole lifetime to mathematical research, regardless of cost. But it is becoming more and more evident that the physicist must know something about the intricate mathematical machinery which has been so successfully employed to bring a large proportion of physical phenomena into one connected theory. We include under this category reversible phenomena. Whether the subject-matter of this book is called dynamics, or the study of quadratic forms, or the theory of geodesics in a hyperspace with special reference to particular definite applications makes no difference. The present reviewer may perhaps be allowed once more to state his conviction that irreversible energy transformations, whether statistical or non-statistical in character, cannot satisfactorily be accounted for as properties of quadratic forms except by the method of energy-accelerations, that is, by studying the *second*, and not the first, differential coefficients with respect to the time of the squares and products occurring in the energy function. But the omission of these phenomena leaves a great portion of modern physics which cannot be properly understood without some knowledge of a very extended and very advanced portion of applied mathematics.

In his preface—which, by the way, is so exhaustive as to leave a reviewer but little fresh to add—Prof. Webster states of the book that "It is obvious that it leads to no particular examinations, from which we in America are to a large extent fortunately free." Examples, as such, are therefore omitted, although most of the standard applications of general principles are included in the text; for instance, motion of a spherical pendulum, the brachistochrone and tautochrone under gravity, potentials of a disc and cylinder, form of a rotating liquid in a uniform field or under self-gravitation, torsion of elliptic and triangular prisms, and so forth. In connection with these applications an intentional feature is very con-